POSITIONING OF PNEUMATIC ARTIFICIAL MUSCLE UNDER DIFFERENT TEMPERATURES

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ABSTRACT

Some researchers have mentioned that temperature creates an important part in the accuracy of positioning of pneumatic artificial muscles (PAMs). However, in literature investigations for measuring temperature inside and outside the PAMs have not been found. This paper presents our robust motion control of these muscle actuators under different temperatures using sliding-mode control.

1. INTRODUCTION

The working principle of the pneumatic artificial muscles is well described in literature ([1], [2], [3], [4], [5] and [6]).
There are a lot of advantages of these muscles like the high strength, good power-weight ratio, low price, little maintenance needed, great compliance, compactness, inherent safety and usage in rough environments. However, problems with the control of the highly nonlinear pneumatic systems have prevented their widespread use [7]. For this, a fast and robust control necessary to achieve the desired motion. Several control ways have been applied to control different humanoid or robot arms, manipulators, prosthetic and therapy devices driven by pneumatic artificial muscles. The early control methods were based on classical linear controllers and then some modern control strategies have been developed (e. g. adaptive controller, sliding-mode controller, fuzzy controller, neural network controller and others) [8].

The layout of this paper is as follows. Section 2 (Materials and methods) is devoted to display our test-bed and different LabVIEW programs. Section 3 (Result and discussion) presents several experimental results. Finally, section 4 (Conclusion and future work) gives the investigations we plan.

Fluid Muscles DMSP-20-200N-RM-RM (with inner diameter of 20 mm and initial length of 200 mm) produced by Festo company were selected for our newest study.

2. MATERIALS AND METHODS

A good background of our test bed and former experimental results of positioning can be found in [9].
The PAMs were installed horizontally and can be controlled by MPYE-5-M5-010-B type proportional valve made by Festo. Our robust position control method based on sliding-mode control. The linear displacement of the actuator was measured using a LINIMIK MSA 320 type linear incremental encoder with 0,01 mm resolution.

To measure temperature inside and outside the muscle the test-bed was completed two thermocouples type K (Figure 1). Figure 2 shows the block diagram of this positioning system with proportional valve.

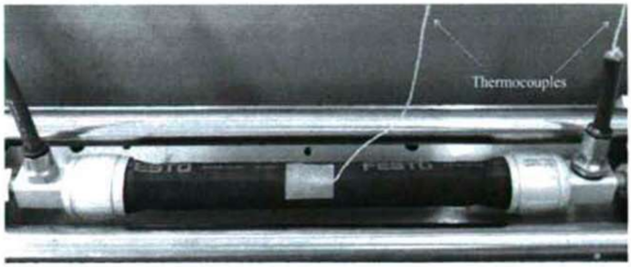

Figure 1. Muscle with two thermocouples

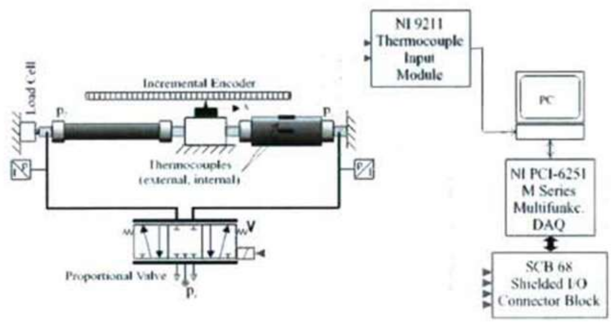

Figure 2. Block diagram of positioning system with proportional valve

The data acquisition and positioning that can be achieved in LabVIEW environment (Figure 3). Aside from the desired position the number of samples and the sampling time can also be set. The data can be saved into a text file.

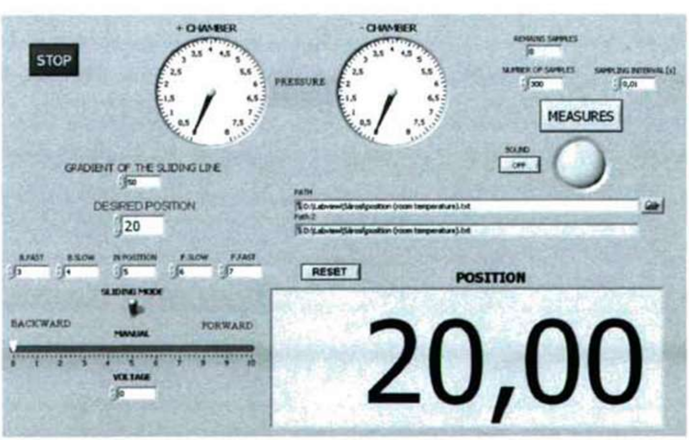

Figure 3. Front panel of LabVIEW program for positioning

The Figure 4 shows the front panel of the LabVIEW program created for temperature measurement. Here the number of samples and sampling time can also be set. During the periodic and automatic working of the muscles the contraction and rate of release can be adjusted with the frequency of the sine wave. The temperature inside and on the surface of the muscle can be read on the indicators on the screen also it is shown as a number. The measured results are saved in a text file for later processing.

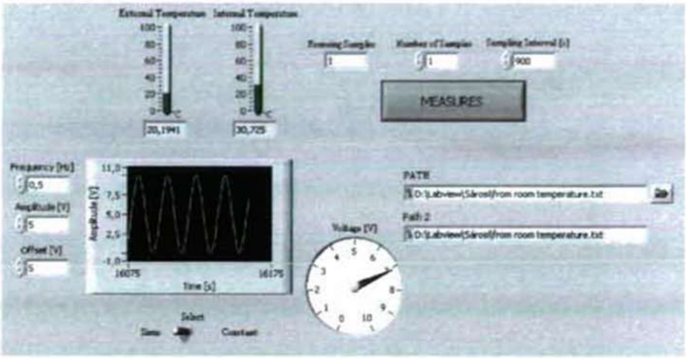

Figure 4. Front panel of LabVIEW program for measuring temperature

3. RESULTS AND DISCUSSION

Positioning was first done in room temperature on the pressure of 6 bar. The desired positioning was set to 20 mm, the number of samples was set to 300, while the sampling rate was set to 10 ms, thus the measurement took 3 s.
Figure 5 shows the positioning as a function of time. It took about 2 s for the position to reach the set value. To show the accuracy of positioning the area around the desired position has been magnified (Figure 6). This Figure shows the accuracy of positioning is within 0,01 mm.

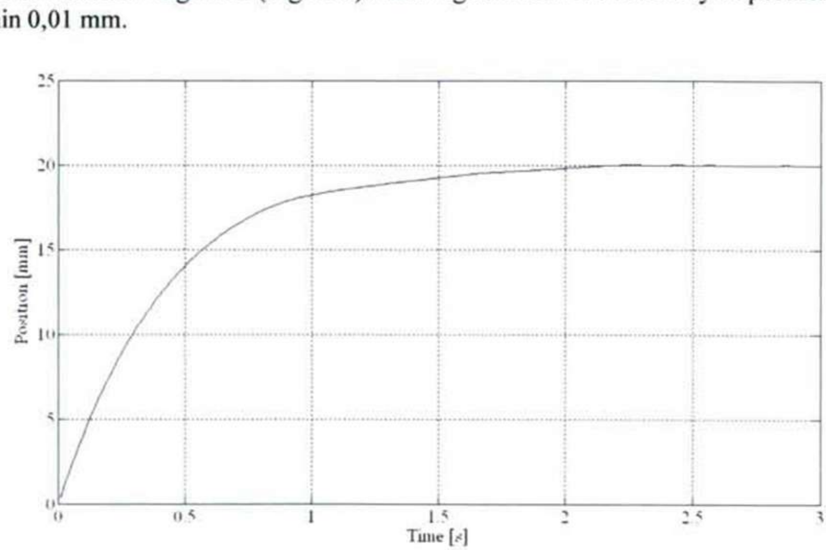

Figure 5. Position as a function of time

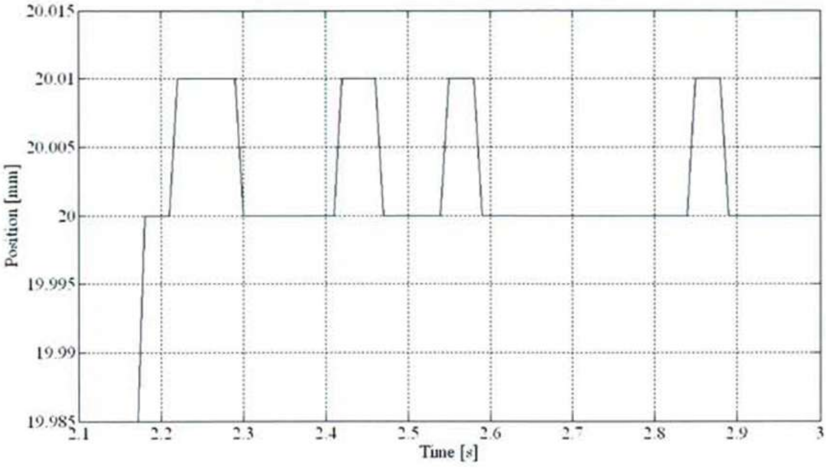

Figure 6. Position as a function of time (enlarged)

The periodic working of the muscles was achieved with a 0,5 Hz frequency sine wave. The measurement took 900 s during which the sampling time was 0,25 s, the acquired data is shown in Figure 7. While the surface temperature reached about 33 °C, the internal temperature oscillated a lot during contraction and release, for this reason a spline approximation was used for the internal temperature (Figure 8).

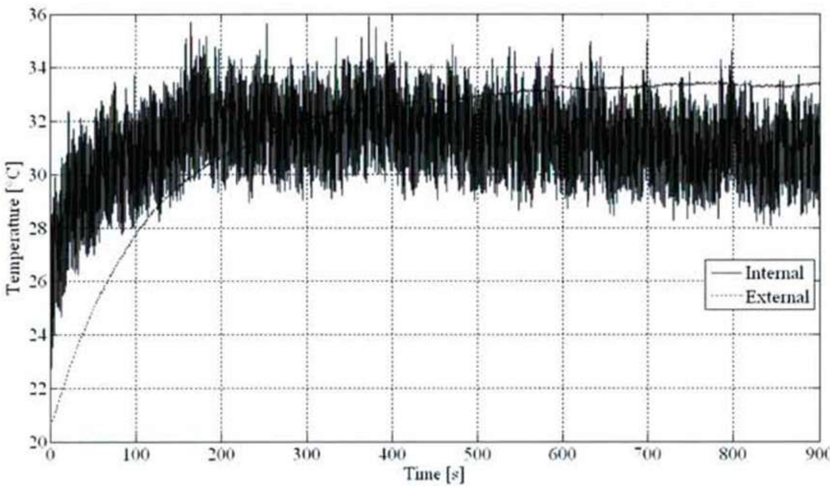

Figure 7. Temperature as a function of time

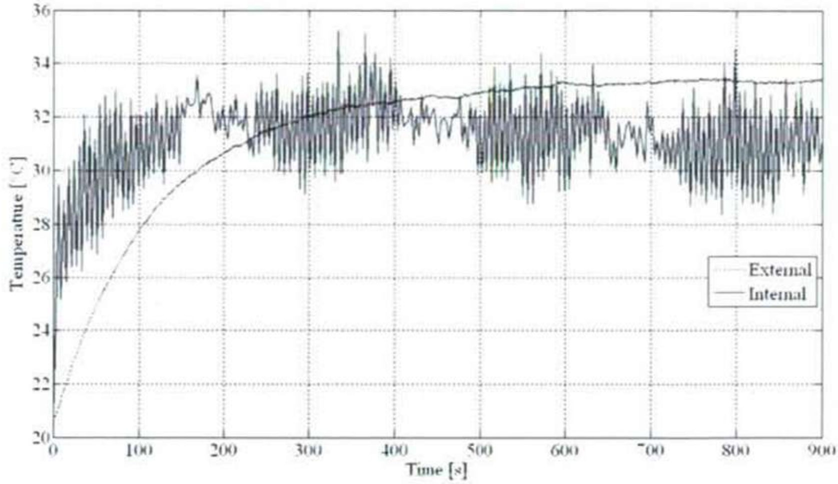

Figure 8. Temperature as a function of time with spline interpolation for internal temperature

After a constant temperature was reached positioning was measured on the pressure of 6 bar, too. The result of it is shown in Figure 9. It shows the desired position was reached within 0,8 s. To show the accuracy of positioning the area around the desired position has been magnified (Figure 10). The accuracy of positioning remained within 0,01 mm.

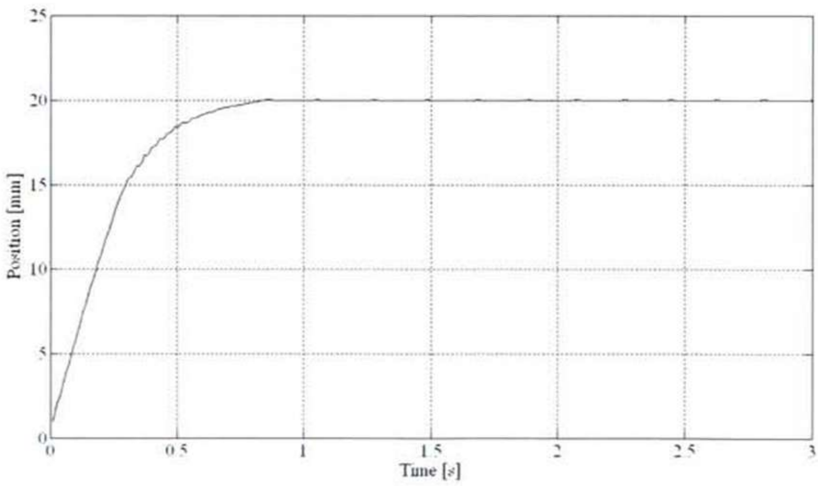

Figure 9. Position as a function of time after work cycle

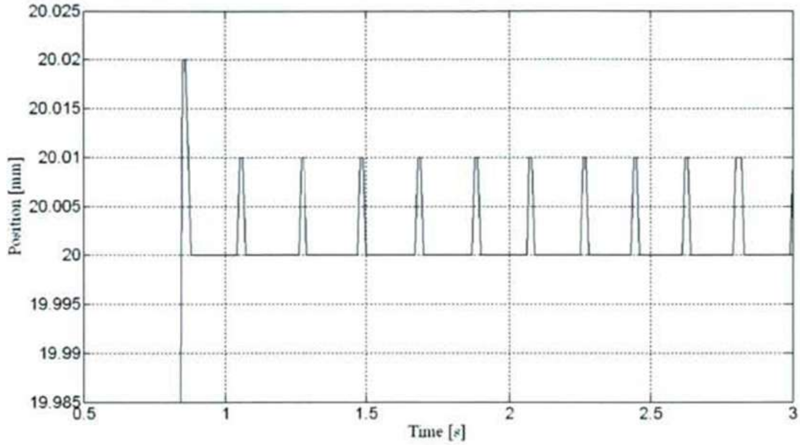

Figure 10. Position as a function of time (enlarged) after work cycle

4. CONCLUSION AND FUTURE WORK

From these measurements the conclusion is that the ideal working temperature of the muscles is not room temperature, but greater than that. To prove it new measurements will be conducted with muscles with varying geometric properties.

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